WRITTEN TESTIMONY OF

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Good afternoon, Chairman Gilchrest and Chairman Radanovich. My name is Stephen Brandt. I am Director of the Great Lakes Environmental Research Laboratory, a research component of the National Oceanic and Atmospheric Administration (NOAA) within the Office of Oceanic and Atmospheric Research.

NOAA is the Nation's premier Federal agency, with responsibilities for enhancing the value of and protecting the vital resources in both marine and Great Lakes ecosystems. The Great Lakes Environmental Research Laboratory (GLERL) is NOAA's leading institution for aquatic invasive species research and has authorization to carry-out such research. Therefore, I am grateful for the opportunity to discuss the scope of the invasive species problem, although I will restrict my comments to aquatic invasive species, given the nature and mission of my agency.

Scope of the Problem

Invasive species now constitute one of the largest present, and future, threats to our coastal ecosystems, our coastal economies, and human health in our coastal regions. Our coastal ecosystems are not just inconsequential bodies of water that happen to be adjacent to the lands we live on – rather, they support and nurture our society and our economy, they harbor and provide valuable natural resources for human use that both feed us (fisheries, water supply) and entertain us (recreational boating, fishing, and swimming), and they protect our shoreline (coral reefs, wetlands & marshes) from the extremes of nature.

Species invasions are now a major global concern, with serious implications and consequences for the United States at National, regional, and local scales. Aquatic species invasions are threatening and impacting coastal ecosystems worldwide and many coastal states are taking or planning some form of protective action. The natural barriers that have limited the range of aquatic organisms are being rapidly overcome by anthropogenic activities. Let me say here that the majority of invasive species vectors are the result of perfectly legitimate activities, which have unintended consequences. I do not wish to be critical of private individuals, or any particular industry, I simply want to highlight that innocent activities can have major, cumulative, long-term affects on our environment.

Ship-borne ballast water is the most significant vector of introductions for aquatic invasive species worldwide (NRC, 1996). Other significant vectors include inadvertent aquarium releases, live-bait introductions, recreational boating and semi-submersible oil platforms. Changes in coastal water quality and coastal habitats can alter the vulnerability of some of the nations coasts to invasions (Carlton, 2001). Invasive aquatic species have caused significant economic losses and ecological disruptions in the U.S. and elsewhere. Invasive species are identified as a leading cause of species extinction and loss of biodiversity in aquatic environments worldwide, perhaps second only to habitat loss (Vitovsek, P. M., H. A. Mooney, J. Lubchenco and J. M. Melillo. 1997. Human domination of Earths Ecosystems. *Science* 277:494-499). Invasive species can replace or eliminate native species, change nutrient and contaminant cycling, affect ecosystem productivity, and can cause losses of economically valuable fisheries. Some invasive species, such as the zebra mussel, can change the structure of entire ecosystems and cause direct economic harm by clogging water intakes for municipal or industrial uses. The resulting economic damages are shared by all natural resource beneficiaries, including industrial and municipal water users, recreational boaters, the fishing public, riparians, vessel operators, and beach users. New Zealand, an island nation particularly vulnerable to aquatic invasions, regards the problem as such a major threat that at the Federal level they refer to it as a National "marine biosecurity" issue.

Scientists have been quick to identify the major species invasion "vectors," these "vectors" being the means by which species are able to move between ecosystems. Increases and changes in ballast water transport, hull fouling, recreational boating, semi-submersible oil platforms, inadvertent aquarium releases, live-bait introductions, canals, and aquaculture are the major ones (Ruiz, G. M., J. T. Carlton, E. D. Grosholz, and A. H. Hines. 1997. Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent, and consequences. *American Zoologist* 37:621-632.; Ruiz, G. M., P. W. Fofonoff, J. T. Carlton, M. J. Wonham, and A. H. Hines. 2000. Invasion of coastal marine communities in North America: apparent patterns, processes, and biases. *Annual Review of Ecology and Systematics* 31:481-531.; Carlton, 2001). To be certain, some natural processes, such as storms, have been responsible for transporting species between separated ecosystems, but human activity has surpassed and overwhelmed both the scope and speed at which nonindigenous species are being delivered to new ecosystems. For example, unwanted alien pests are entering Hawaii at a rate estimated by the U.S.G.S. to be about 2 million times more rapid than the natural rate (http://www.hear.org/); a Canadian study based on DNA and genetics calculated that human-mediated dispersal of crustacean zooplankton now exceeds natural dispersal by up to 50,000 times (Hebert, P. D. N. and M. Cristescu. 2002. Crustaceans, invasions and genes. *Can. J. Fish. Aquat. Sci*. 59:1229-1234).

Ballast water transport and discharge is, by far, the most universal and ubiquitous of the major aquatic invasion vectors and represents the greatest immediate threat to most coastal state ecosystems. Over two-thirds of recent, non-native species introductions in marine and coastal areas are likely due to ship-borne vectors (Ruiz, G. M., P. W. Fofonoff, J. T. Carlton, M. J.

Wonham, and A. H. Hines. 2000. Invasion of coastal marine communities in North America: apparent patterns, processes, and biases. *Annual Review of Ecology and Systematics* 31:481-531). The rate of introductions in various coastal ecosystems continues to increase with expansion of trade and the speed of transportation. There are an estimated 35,000 ships plying the oceans today. James Carlton, a noted scientist, once estimated that at any time of day there are several thousand aquatic species being carried in the ballast tanks of ships moving between coastal states (Carlton, J. T. 1999. The scale and ecological consequences of biological invasions in the world's oceans. In Invasive Species and Biodiversity Management. O. T. Sandlund, P. J. Schei, and A. Viken, eds. Kluwer Academic Publishers, Dordrecht, Netherlands. 195-212; Carlton, J. T. 2001. Introduced Species in U. S. Coastal Waters: Environmental Impacts and Management Priorities).

Ballast water is not only ubiquitous, but carries organisms ranging from human pathogens to fish. The port states of Brazil and Argentina require some ships to chemically disinfect their ballast tanks before being allowed entry rights, because of the fear of human pathogens such as cholera. A November 2000 report in the science journal *Nature* documented the presence of both types ("serotypes" O1 and O139) of cholera bacteria that are associated with human epidemics in the ballast tanks of 93% of ships sampled in Chesapeake Bay.

However, ballast water is not the only vector of importance in some regions. There are 24 species of non-native algae in Hawaiian waters at present, some of which have taken over whole areas of coral reef. Some of these algae have been introduced via hull fouling. Inappropriate release of aquarium species is a major source of nonindigenous species in Hawaii's inland freshwater streams and ponds (ANS Task Force Meeting, November 2002).

In the Great Lakes region, ballast water, escape from aquaculture sites, and the aquarium and bait trades appear to be the most significant vectors. The most recent known potential aquatic invasion threat comes not from ballast water, but from a combination of aquaculture and canals – as the committee members may know, three species of large Asian carp (silver, black, and bighead) that escaped from aquaculture sites in our southern states are moving up the Mississippi River system and are within striking distance of the Great Lakes via the Chicago Sanitary and Ship Canal. An electronic barrier has been set up in the canal to try to stop the spread of this introduction into the Great Lakes.

All mainland coasts of the United States — East, West, Gulf, and Great Lakes, as well as the coastal waters of Alaska, Hawaii, and the Pacific Islands—have felt the effects of an ever increasing number of successful aquatic species invasions. I suspect that members of this committee are already familiar with some of the gross statistics – 202 known or possible nonindigenous species in Chesapeake Bay (Smithsonian Environmental Research Center, Edgewater, Maryland, Mariner Invasion Research Lab website: http://invasions.si.edu/Regional/reg_chesapeake.htm), over 230 in the San Francisco Bay estuary (National Invasive Species Council. 2001. Meeting the Invasive Species Challenge: Management Plan. 76 pp), at least 162 in the Great Lakes waters (Mills, E. L., J. H. Leach, J. T. Carlton, and C.L. Secor. 1993. Exotic species in the Great Lakes: a history biotic crises and anthropogenic introductions. *J. Great Lakes Res*. 19: 1-54.; Ricciardi, A. 2001. Facilitative interactions among aquatic invaders: is an "invasional meltdown" occurring in the Great

Lakes? *Can. J. Fish Aquat. Sci.* 58:1-13.), at least 544 in the 5-state Gulf of Mexico coastal system (USEPA (U.S. Environmental Protection Agency). 2000. An Initial Survey of Aquatic Invasive Species Issues in the Gulf of Mexico Region. Version 4.0. Table 5. EPA 855-R-00-003. September 2000.) and in Pearl Harbor and Honolulu, almost half the species are non-native. Prince William Sound, Alaska is the recipient of large amounts of ballast water originating from the west coast of the U.S., including San Francisco Bay, an invasive species hot spot.

The effects on the invaded ecosystems of many of these foreign species have appeared – to the casual human observer – to be minimal. However, **once established in an ecosystem, an invader, by definition, changes that ecosystem.** Each new invader will have its own niche, type of effect, degree of change it produces, and timing with which its impact may become discernable. Losses in one part of an ecosystem can reverberate throughout the ecosystem to affect all resources within it. Our coastal ecosystems function in finely tuned balance that evolved over millennia. When that balance is disrupted, such as by changes in the structure and function of the food web through shifts and reductions of important native food web components, the services and benefits provided by the ecosystem are put at risk, and affect our economy through loss of resource value or added expenses to recover, restore, and maintain desired resource values.

Some Examples

First, from my own backyard – the Great Lakes. Great Lakes resource managers have been cognizant of this problem, and have been dealing with managing invasive species for nearly half a century. The sea lamprey and alewife were two of the key invaders into the Great Lakes in the 1950's, having reached the upper lakes aided by the interconnecting canals. These invaders were costly to the Great Lakes. Management efforts have been directed at control either though direct means (with the sea lamprey) or through the introduction of a predator, the Pacific salmon, for the alewife. The sea lamprey, the Great Lakes' oldest documented aquatic invader, caused the collapse of fish species that were the economic mainstay of a vibrant Great Lakes fishery. Before sea lampreys entered through canals, the United States and Canada harvested about 7 million kgs. (15 million lbs.) of lake trout in lakes Huron and Superior annually. By the early 1960s, the catch was only about 136,000 kgs. (300,000 lbs.). The fishery was devastated, with losses in the billions (Great Lakes Fishery Commission web site: http://www.glfc.org).

Extensive scientific research, during which over 6,000 chemicals were tested, identified a chemical treatment leading to a program that controls, but cannot eradicate, the lamprey. The cost to the United States and Canada has increased over time and is now about $14M per year. However, I would also point out that for a $14M per year expense, lake trout and salmon recreational sport fisheries valued at an estimated $4B became possible again and are thriving.

More recently, the zebra mussel invasion into the Great Lakes has captured the attention of the nation on this issue. You are likely familiar with the zebra mussel – which we refer to as the "poster child" for aquatic species invaders. The Great Lakes basin is the aquatic gateway to the heartland of America and a hot spot for aquatic species introductions to major interior sections of the U.S. While the spread of aquatic species introduced in most U.S. coastal ecosystems is generally restricted to adjacent contiguous coastal ecosystems, the Great Lakes provide a pathway for freshwater-adapted invasive species to spread throughout the interior waters of the central and eastern United States. One need only examine the spread of zebra mussels to understand this – they are now found outside the Great Lakes – St. Lawrence River system as far west as eastern Arkansas, as far south as the Mississippi delta below New Orleans, Louisiana, and east as far as the Hudson River estuary north of New York City. You have probably heard of the economic costs attributed to zebra mussels clogging water intake pipes. They have fouled industrial and municipal water intakes, which must now be chemically treated on a regular basis throughout the summer months to keep them flowing. Estimates of the annual cost of zebra mussel control and mitigation range from $100 to $400 million per year in the Great Lakes basin, but the zebra mussel has already spread throughout most of the eastern half of the country.

Do you know that the zebra mussel is also responsible for the repeated reoccurrence of blue-green algae blooms in certain large areas of the Great Lakes? These algae produce a toxin known as microcystin. These algae also cause water quality taste and odor problems in the municipal water supplies in affected areas. Research at the NOAA Great Lakes Environmental Research Laboratory has also implicated the zebra mussel in the slow, but steady elimination of *Diporeia*, a shrimp-like animal that has been a dominant bottom-dwelling organism in the Great Lakes since their formation at the end of the Ice Age. *Diporeia* are the primary food source for lake whitefish, a commercially valuable fish species in the Great Lakes. Loss of *Diporeia* is an example of an invasive-species caused food web disruption that can be directly linked to declines in the body condition of lake whitefish. As a result, lake whitefish are becoming thinner and less marketable for the commercial fisheries. *For several fish species, including bloater (*Coregonus hoyi*), whitefish (*Coregonus clupeaformis*), slimy sculpin (*Cottus cognatus*), yellow perch (*Perca flavescens*), and trout-perch (*Percopsis omiscomaycus*),* Diporeia *is the principal prey. These fish are, in turn, the primary food of the trout and salmon that support most of the Great Lakes sports fishery. Research is examining the impact of this disappearance on the $4B sports fishery.* Moreover, declines in the popular yellow perch population in Lake Michigan followed the establishment of zebra mussels and are also believed to be directly linked to some form of ecosystem or food web disruption. The more we know, the better we can mitigate economic losses

In San Francisco Bay, the introduced clam *Potamocorbula amurensis* is such an efficient filter feeder that it has eliminated phytoplankton blooms in the northern portion of the Bay. Since phytoplankton are at the very base of the food chain, it is expected that there will be cascading impacts throughout the food chain. Studies have also demonstrated that populations of zooplankton and mysid shrimp in San Francisco Bay have dropped. Although there has been little research on the next link in the chain, the fact that juvenile fish feed on zooplankton and mysid shrimp should raise concern. In most food chains the higher organisms – clams, mussels, and fish, for example- are often the basis for economically valuable fisheries, and the implications of cascading food web disruption include loss of fishery value, loss of recreational (fishing) opportunity, and loss of income and jobs. A recent study has raised another issue related to this invasive clam species. Researchers have found very high selenium concentrations in the clams, which could have an impact on birds and fish that feed on them.

In the Chesapeake Bay, resource managers are very concerned about the potential impact on native Bay species of the recent invader, the veined rapa whelk (*Rapana venosa*), a gastropod mollusk originating from the Sea of Japan. Since it feeds on bivalve mollusks, the Bay's clams and oysters are threatened by the spread of the rapa whelk.

Also in the Chesapeake Bay, and in Louisiana, coastal wetlands are being lost due to the voracious appetite of the introduced nutria.

A University of Hawaii study estimated the cost of invasive algae to be $20 million per year for the island of Maui alone.

In summary, invasive species are ubiquitous and represent a global scale problem, but with impacts and economic costs hitting us at the national, regional, and local scales. Aquatic invasive species affect virtually every coast of the United States. The invaders range from bacteria and human pathogens, to plants, to small and large aquatic animals. In aquatic ecosystems, the rate of invasions is accelerating as the magnitude of travel and trade increases and as the speed of transporting materials increases. There is no doubt that such invasions have major economic and environmental consequences and affect each of us individually.

Efforts to Prevent, Control or Eradicate

<u>Prevention</u>

Before touching on control activities, I think that it should be emphasized that prevention is our first and most important line of defense against species invasions. Control is often much more expensive than prevention, and sometimes becomes an ongoing expenditure. The example of the sea lamprey provided earlier in this testimony illustrates this. An investment made to prevent an introduction is quite often the most cost effective method of dealing with a potential problem.

The Members of this subcommittee are likely familiar with the concept of ballast water exchange, its use as an invasive species risk reduction method, and its limitations. To address the serious limitations to mid-ocean ballast water exchange, Congress initiated a competitive research program by adding §1104 of the National Invasive Species Act of 1996, which is administered for the Department of Commerce by the NOAA Sea Grant Program Office in partnership with the Department of Interior's Fish and Wildlife Service (FWS) and the Maritime Administration (MARAD). This program was designed to encourage development and demonstrate technologies and practices that will prevent nonindigenous aquatic species from being introduced into the Great Lakes and other waters of the United States. Projects funded under this program are selected through an annual peer-reviewed open competition process.

The Ballast Water Technology Demonstration Program has funded projects covering all stages of technology development and demonstration, from bench-scale investigations through pilot scale demonstrations, including some full-scale field tests on ships engaged in commercial activity. Additionally, NOAA invites the submission of additional ballast water research proposals through the more general aquatic nuisance species competitive grant program administered by the National Sea Grant College Program under §1202(f) of the Act. Shipboard tests have occurred for eight of nine ballast treatment techniques discussed in the 1996 National Research Council report titled, *Stemming the Tide: Controlling Introductions of Nonindigenous Species by Ships' Ballast Water*, as well as for some newer technologies not covered in that report.

Since 1998, the technologies being investigated have matured so that more projects involve full-scale tests of ballast water treatment equipment and fewer involve small laboratory scale experiments. These shipboard tests have brought us significantly closer to the development of mature ballast water treatment technologies, but none is ready for widespread use by the maritime fleets of the world. There is general consensus that "there is no currently universal technological solution, nor is there likely to be one in the very near future, and mid-ocean ballast water exchange is currently the only practical ballast water management option. . .(direct quote from *Harmful Aquatic Organisms in Ballast Water*, submitted by the United States to the International Maritime Organization, Marine Environment Protection Committee, 48th Session, Agenda Item 2, July 17, 2002).

The difficulty arises when attempting to move these technologies to full-scale shipboard testing under operational conditions. Limitations of space and power on commercial vessels, and limitations in the rate of ballast water treatment that can be achieved with systems amenable to shipboard retrofit, have so far precluded any near-future practical application of these technologies on all but a few small vessels in the existing commercial fleet. In addition, actual full-scale testing of these systems relies of the availability of suitable commercial ships as test platforms. While the industry has been generally supportive and has made operating vessels available for testing, commercial ships operate on very tight, yet changeable schedules, and first and foremost they operate to serve their commercial clients. Any experimental testing of ballast water treatment systems must be done on a "not to interfere" basis. This means that the scientists and engineers attempting to test and verify their systems at operational scale and under operational conditions, do not have full control over the test timing or test conditions. Commercial ships cannot readily be delayed or diverted to rerun an experiment or to adjust testing conditions.

NOAA recognizes that continued work is needed in all areas of prevention, not just ballast water technology research. NOAA's National Sea Grant Program has played a major role in defining the research agenda on aquatic nuisance species, including ballast water research. The 2000 report, "Aquatic Nuisance Species Report: An Update on Sea Grant Research and Outreach Programs," documented work on 22 species in 24 states, the largest of its kind. Sea Grant programs have been instrumental in the development of state invasive species management plans on every coast, and have been leaders in working with the bait and aquaculture industries to mitigate inadvertent introductions. Sea Grant developed the Hazard Analysis and Critical Control Point (HACCP) approach to identify and correct practices that could present a risk of invasive species. This HACCP program is now in use in fish hatcheries in many states and by the U.S. Fish and Wildlife Service.

Complementing the broad resources Sea Grant brings to the university community, the NOAA Great Lakes Environmental Research Laboratory is in the final year of a three-year, multi-institutional research program to assess the risk of invasion posed by No-Ballast-On-Board

("NOBOB") vessels in the Great Lakes. NOBOB vessels are those that do not carry pumpable ballast water as they enter the Lakes fully loaded with cargo. However, residual ballast in their tanks have now been documented by this research to contain live organisms and dormant viable eggs of invertebrate and algal species. These residuals can mix with lake waters brought on as ballast when cargo is offloaded at ports in the Great Lakes, which may eventually be discharged in other ports. The results of the NOBOB research are already being made available and should assist the shipping industry and regulators in determining best management practices for reducing the amount of residual sediment and live organisms in ballast tanks. Another part of that program is evaluating the effectiveness of mid-ocean ballast water exchange as a barrier to potential invasions, with several experiments being planned for this year.

In recognition of the likely long-term use of ballast water exchange as an invasive species management option, GLERL, in partnership with the Navy and with the assistance of the shipping industry, is just beginning to explore the use of computer modeling and computational fluid dynamics to better understand the mechanics and dynamics of fluid flow in a ballast tank during exchange. We hope that this will help identify ways to improve the consistency and efficiency of exchange, thus improving the level of protection ballast water exchange may provide for our coastal ecosystems. The proposal for this research was competed and funded under the Ballast Water Technology Demonstration Program.

Control

There is a tendency to equate control activities with eradication, but they actually encompass a wider range of options. Once an invasive species is established and widely distributed, eradication is often not possible. Under such circumstances, control activities may include reducing the size of populations, containing the invasion, or mitigating the impact of a species. Harmful affects can often be minimized with early detection, understanding, and prediction of potential impacts and adaptive management.

We can learn much about controlling invasive species from our counterparts on the terrestrial side, who, at least in the area of agriculture, have been dealing with the issue for more than a century. However, there are many ecological, biological, logistical and economic issues related to controlling aquatic invaders that have no counterpart on the terrestrial side. In these situations, new research must be conducted and totally new control tools devised. As an example, two summers ago we were confronted with a major bloom of Australian spotted jellyfish in the northern Gulf of Mexico. They were so plentiful that shrimpers had to stop fishing because they could not cast their nets without the jellyfish clogging them. A rapid survey in areas where the jellyfish were most abundant showed that they were removing virtually 100 percent of zooplankton from the water column. We recognized immediately that this was a major food web disruption in the making, but we were confronted with the fact that no one had ever tried to control jellyfish populations in the past, and we had no idea of how to accomplish control measures. Although this particular infestation died off, we are researching responses for the next time the situation occurs.

We are also having to learn how to conduct biocontrol in ways our terrestrial counterparts have never had to consider. Biocontrol is the introduction of a predator or pathogen that affects an invasive species. It is a well-established technique for control of terrestrial invasive species such as weeds. Before such an introduction takes place, it is important to determine that the biocontrol agent does not cause unintended harm to native species and is safe for humans. The Army Corps of Engineers and the Department of Agriculture have been successful in finding biocontrol agents for some aquatic plants such as alligator weed and purple loosestrife, and there is research directed toward other aquatic plant species such as giant *Salvinia*, *Hydrilla*, and *Spartina*.

However, very few biocontrol agents have been developed for aquatic animals. With guarded optimism, I would like to report, however, that research supported jointly by NOAA Sea Grant and FWS, may have had a breakthrough in this area. *Pseudomonas* bacterium, a pathogen that destroys the digestive gland of zebra mussels, has been discovered, and it appears not to harm native species of mussels or other animals. The scientists who found the *Pseudomonas* bacterium looked at over 600 different pathogens. Although early results are promising, it is important that further research verify that the agent poses no risk to native mussels, the environment, or human health.

I would also like to mention another important control activity – education and outreach. Educating user groups can be an especially effective tool. This is particularly true in the case of invasive aquatic species, and the Aquatic Nuisance Species Task Force is making a concerted effort in a couple of areas. One of the most significant pathways for the <u>spread</u> of successful invaders such as zebra mussels and aquatic plants is recreational users. Such species are often carried from one body of water to another by boats. The Aquatic Nuisance Species Task Force has made a concerted effort to reduce boating as a pathway for introduction. NOAA, FWS, and the Coast Guard have all funded efforts to educate boaters. There is evidence that such an approach may help contain invasive species. A recent study by Minnesota Sea Grant comparing states that had aggressive education campaigns with states where very little was being done, showed that education can not only increase boater awareness, but also change boater behavior. In addition, the 100th Meridian project funded by FWS has, so far, prevented the spread of zebra mussels to western states on recreational boats. A major challenge looming in the near future may be to prevent or respond to the unintentional spread of aquatic invasive species, like the zebra mussel, during the Lewis and Clark Bicentennial celebration starting this year.

<u>Eradication</u>

While eradication is usually much more difficult and expensive than prevention, it can sometimes be accomplished when the necessary players can react quickly and work together. With fingers crossed, I would also like to report the apparent successful eradication of a species that has received considerable attention recently–*Caulerpa taxifolia*, the so-called "killer algae of the Mediterranean." *Caulerpa* was found in a lagoon just north of San Diego in the summer of 2000. After two and a half years work to eradicate a rather small infestation in a cooperative effort involving several Federal and State of California agencies, we now have gone two consecutive quarters without detecting any new growth of the invasive algae.

The *Caulerpa* eradication project illustrates two important points. First, eradication efforts, even small ones, are expensive. It has cost the State of California and other contributors (including

NOAA) over $4 million to eradicate this rather small infestation, and the monitoring necessary to ensure that eradication is complete will increase this amount. Second, in most instances, control and eradication efforts require active partnerships with State governments. Not only do they have primary jurisdiction over most areas, but they also have more on-the-ground resources available.

Another example of an apparently successful eradication was reported in connection with the African sabellid polychaete worm, introduced into California coastal abalone farms in the mid- to late-1980s via an imported South African species. These worms infest and weaken the shells of the California abalone, reducing growth rates and production, and thus, their value. Sea Grant sponsored researchers showed that these worms can also infest many types of native marine snails, not just abalone. In the late 1990s researchers completed a reportedly successful project to eradicate the sabellid from a coastal area where it had been transmitted to native gastropods. However, there are recent reports indicating that a few isolated cases may still remain or that the pest has reemerged in a few locations. This illustrates just how difficult it can be to achieve total eradication of an aquatic pest.

Early Detection and Rapid Response

Early detection is necessary before we can have any hope that rapid response may be potentially successful. To this end NOAA's National Ocean Service has established a pilot project with the Bishop Museum in Hawaii to conduct early detection monitoring for new invaders in key Oahu harbors and bays. If successful, NOAA will expand the program to other coastal regions as resources permit. However, early detection may prove problematic, since it is difficult to know, for any particular ecosystem, where to focus monitoring, what to look for, and when to look, yet the alternative, a broad an unfocused monitoring program, can rapidly become expensive and untenable. As NOAA develops this program it will explore these issues through applied research to develop new or modified monitoring techniques and tools.

Rapid response to new species invasions may help managers, industries, and researchers establish the nature of a new invasive species, its current and potential distributions, vectors of dispersal, potential ecological and industrial impacts, and potential control and/or eradication options. For example, when notified of a new invasive species in the U.S., the Animal and Plant Health Inspection Service (APHIS) under the U.S. Department of Agriculture, one of the oldest invasive species-fighting organizations in the United States, organizes a 'New Pest Advisory Group' consisting of government officials and appropriate experts. This group meets and acts quickly to discuss the known biology of the organism, its potential damage and range, mitigation strategies, and possible actions. Based on these discussions, the group makes a recommendation to APHIS to either take action, or not, on the newly detected exotic pest. This process was used to respond to the discovery of the invasive "pine shoot beetle" in 1992 on a Christmas tree plantation near Cleveland, Ohio. Within a few days of being notified, APHIS brought together concerned parties from industry, academia, and state and federal agencies in a "New Pest Advisory Group" to share information and develop response strategies. Through this process, they were able to rapidly establish the extent of its distribution and potential impacts on industry, and start the process to develop a regulatory response.

At the present time, no framework exists to support and carry out rapid scientific assessment of new aquatic invader populations. Yet gathering and verifying information and compiling summary findings and recommendations is a necessary precursor to supporting informed and effective resource management decisions that do not waste taxpayer funds on costly eradication attempts that have little chance of success. When a new invasion is reported, a team of appropriate experts needs to be quickly assembled to gather and verify information and assess whether the invasion is a candidate for attempted eradication or control. A framework needs to be developed under which a rapid scientific invasion assessment team can be assembled and activated in response to reports of new species. Rapid assessment of new AIS arrivals can be useful in helping resource managers become aware of new demands on the ecosystem and to plan management actions. For example, the Fish Health Committee under the Great Lakes Fishery Commission has developed a model program and risk assessment guidelines for evaluating new fish diseases that may be useful in developing a similar framework for aquatic invasive species.

What if We Fail (to Prevent, to Control, to Eradicate)

Once a species has become established in an ecosystem, the ecosystem, by definition has changed, and the species is nearly impossible to eradicate. An invader redefines the ecosystem. Unlike many chemical contaminants that dissipate through time, invasive species do not have a 'half-life' and they are here to stay. We can try to contain the species, but it is very difficult to actually control the species in large ecosystems, and there is no silver bullet for control because each new invader has its own unique life history and place in the ecosystem. Thus, for many invasive species, control may entail finding methods of reducing their impact, or, lacking any viable control or eradication, humans may have to adaptively manage the affected ecosystems and resources. Long-term changes in an ecosystem caused by an invader may necessitate adapting our management of water quality and economically valuable resources, such as fisheries, to the altered conditions. This requires revision of management strategies (i.e., adaptive management) that can only be accomplished on the basis of scientific understanding of the changes that have occurred. How can this be done?

Of fundamental importance are the following concerns: *How does that changed ecosystem affect the ecology and economy of the region? What will be the extent of the impact? And can we adapt our management strategies to accommodate its presence?* This requires answers to two critical and equally important questions:

> (1) What is the basic biology, life history, and reproductive strategy of the invasive species?
>
> and
>
> (2) How will this new species fit into and change the ecosystem functioning?

The answer to the second question clearly demands that we know how the ecosystem functions to begin with. Fundamental ecosystem understanding and long-term data sets will lead to early detection and evaluation. Once there is a basic understanding of the ecosystem, assessing the role of each new invader is somewhat easier. In contrast, once a species enters, it is too late to ask, what was the ecosystem like before the invader arrived? A study that lasts only 1-2 years is insufficient because the natural year-to-year variability in an ecosystem can be high or unknown.

For example, over the last 15 years the Great Lakes have undergone a new wave of species invasions dominated by exotic invertebrates- zebra mussels, quagga mussels, the spiny waterflea and the fishhook waterflea. Unlike previous invasions in which vertebrates dominated (e.g., sea lamprey and alewife), these invertebrates inserted themselves in the lower trophic levels and thus disruption percolates up through the food web with potentially serious consequences to fish communities. This bottom-up effect on the food web eliminates the potential application and modification of existing fisheries models to make fishery management decisions. Scientists at GLERL, in partnership with the Great Lakes Fishery Commission, are conducting research to quantify and develop tools for forecasting the rate and extent of food web impacts of these four invaders for use in assessing the need to revise fishery management plans in the Great Lakes.

Legal Gaps

One of the action items listed in the National Invasive Species Management Plan is for the National Invasive Species Council to conduct an evaluation of the current legal authorities relevant to invasive species. The evaluation is to include an analysis of whether and how existing authorities may be better utilized. Once this review is finished, and if warranted, recommendations will be made for changes in legal authority.

The Congress anticipated one emphasis of this Administration in 1990 when it set up a structure that encouraged coordination and cooperation among several Federal agencies. As I have pointed out in this testimony, there are significant areas in which agencies on the Aquatic Nuisance Species Task Force are establishing priorities together, sharing expertise, and jointly funding specific actions. This same concept has been carried through in the broader Invasive Species Council. This Administration has made more efficient use of resources–whether human or financial–a priority. Such cooperation and coordination is particularly important in the area of invasive species where partnerships with other Federal agencies and State governments are often necessary. At the urging of the Administration, a pilot crosscutting budget on invasive species was prepared for FY 2004, which included interagency cooperative activities. In FY 2005 the plan is to expand the invasive species activities included in the crosscut.

Finally, the invasive species problem is nationwide and is most effectively coordinated at the national level. However, implementation at the regional (coastal) or ecosystem level is most practical and makes the most sense, since different U.S. ecosystems will have different invasive species issues and characteristics, i.e., the ecological and economic impacts, source regions, mechanisms, and pathways for invasion will not be the same, nor of the same importance.

Working to Find Solutions

We were asked how to solve this vexing problem. It will take time, resources, long-term dedication, and the national will. I suspect that the problem will never be totally solved.

Because species invasions are so closely linked to human economic and recreational activities, I can guarantee you that there will be new introductions despite our best efforts. Control efforts will still be needed both for new introductions and for those species already here. We can, however, reduce the number of new introductions by interdicting the most significant pathways. There is promising new research on genetic engineering coming out of Australia that may provide a way to eradicate certain invasive species. And, we can reduce the impact of species that have been introduced by detecting them and responding quickly, and by learning how to best adapt to those that are successful.

We can also reduce the impact of invasive species by developing new tools for control and by more effectively coordinating our utilization of resources, not only among the various Federal agencies but also with our partners on a State and local level. As demonstrated by the eradication of *Caulerpa* through a joint State, Federal and university partnership and by the unparalleled continuing contributions of Federally funded programs to advancing invasive species research, and providing useful management tools and solutions, preventing and controlling invasive species is a task that will only be successful if the Federal government has adequate resources and authority to work closely and quickly with the States, universities, and citizens in regions affected by aquatic invasions.

Because the problem will continue into the future, we must recognize that a continuing commitment is necessary. Although it is certainly ambitious, the National Management Plan prepared by the Invasive Species Council does provide a good blueprint for the range of activities that will be necessary to fully address the invasive species issue.

Particularly in marine and coastal areas, the science of biological invasions is still very young, and we are still learning, yet significant progress has been made in some areas. There is, however, much more that remains to be accomplished. As a trustee for marine and coastal resources, NOAA recognizes the importance of this issue and will continue in our efforts to deal with aquatic invaders. To this end, I am pleased to report that, under the leadership of Vice Admiral Lautenbacher and with the active support and involvement of Deputy Assistant Secretary Timothy R.E. Keeney, NOAA has incorporated Aquatic Invasive Species as a major theme in its new strategic plan. GLERL and the National Sea Grant Program Office have worked together with other elements of NOAA towards this end. GLERL is charged with leading the development of the NOAA-wide implementation plan. The plan will include elements of prevention, monitoring for early detection, rapid response, and management (eradication, control, adaptation) of successful invaders, as well as international cooperation and information exchange, and coordination with external programs under the National Sea Grant Program. The plan is being developed in an inclusive cross-NOAA process, after which it will be distributed to our constituent and partner communities for comments and suggestions prior to being finalized.

Underpinning all elements of the NOAA plan will be a broad program of coordinated NOAA research, involving NOAA labs such as GLERL and their external partners, as well as the National Sea Grant Program network. As pointed out in the National Management Plan (National Invasive Species Council, 2001), *"Research supports each aspect of the Plan. Research assists policy makers in assessing gaps in authority and program policy, and it* *supports invasive species resource optimization, prioritization, and public outreach efforts."* In order to maximize use of NOAA's scientific resources and to assure cross-NOAA prioritization and coordination of research activities, NOAA is in the process of creating a ***National Center for Aquatic Invasive Species Research***, to be housed at and administered by GLERL.

Chairman Gilchrest, Chairman Radanovich, and Members of the Subcommittee, this concludes my testimony for today. Thank you for the opportunity to testify, and I would be happy to respond to any questions that the Subcommittee may have.